-continued

$$\left\{\left[\frac{(x-\delta)^2+w^2+y^2}{2(x-\delta)}\right]^2-w^2\right\}^{\frac{1}{2}}\Bigg)$$

where

$$w^2=(h-\delta)^2+2a(h-\delta) \tag{14}$$

$$\delta=\frac{h^2+2ah}{2(a+b+h)} \tag{15}$$

Equation (13) represents a special case of Equation (7).

Defining,

r_D=radius of curvature of DP sphere

r_R=radius of curvature of RP sphere

The equation of the progressive surface may be written:

Distance Portion:

$$f(x,y)=r_D-(r_D^2-x^2-y^2)^{\frac{1}{2}} \tag{16}$$

Progressive Zone (from Equation (3)):

$$f(x,y)=\zeta(u)-\{r^2(u)-[x-u+r(u)\sin\theta(u)]^2-y^2\}^{\frac{1}{2}} \tag{17}$$

where

$$\sin\theta(u)\equiv\frac{u-\xi(u)}{r(u)} \tag{18}$$

$$=\int_O^u\frac{du}{r(u)} \tag{19}$$

$$\xi(u)=r(u)\cos\theta(u)+\int_O^u\tan\theta(u)\,du \tag{20}$$

$$\frac{1}{r(u)}=\frac{1}{r_D}+\left(\frac{1}{r_R}-\frac{1}{r_D}\right)(c_2u^2+c_3u^3+c_4u^4+c_5u^5) \tag{21}$$

$c_2=10/3h^2$
$c_3=O$
$c_4=-5/h^4$
$c_5=8/3h^5$

u(x,y) is given by Equation (13);

Reading Portion:

$$f(x,y)=\zeta(h)-\{r_R^2-[x-h+r_R\sin\theta(h)]^2-y^2\}^{\frac{1}{2}} \tag{22}$$

For simplicity, the above equations have been presented for the case in which the beginning of the progressive corridor coincides with the center, O, of the lens blank. It may be desirable, however, to decenter the entire progressive surface up or down, right or left, relative to the geometrical center O. The equation of the decentered surface relative to the original system of coordinates is obtained by replacing x and y in the above equations by x-d_1 and y-d_2, respectively, where d_1 and d_2 are the x and y values of decentration.

The progressive surface generally defined by Equations (13)-(22) will now be evaluated for a lens having a reading addition of 3.00 diopters. The lens is assumed

to have an index of refraction of 1.523, and the following values of the parameters are assumed

a=10.00 mm
b=91.0 mm
h=16.0 mm
r_D=84.319 mm
r_R=57.285 mm
d_1=2.00 mm
d_2=0.00 mm

FIG. 9 shows the results of an electronic computer evaluation of the equations, using the given values of the parameters. Because the lens is symmetrical about the vertical meridian, only the right half is shown. This figure gives the elevation of the surface above the x-y plane, computed at 4 mm intervals. Because the x-y plane is tangent to the lens surface at the point x=−2, y=0, the elevation at x=y=0 is non-zero.

When a square grid is viewed through a progressive lens of the invention the distorted pattern of the grid provides information about the distribution and strength of the lens aberrations. The grid pattern produced by the lens described above is depicted in FIG. **10**. In this diagram, the lens was rotated 9°, as it would be when mounted in a spectacles frame. It will be seen that the grid lines are continuous, smoothly flowing, and uniformly distributed. Note also that the grid lines in the periphery of the temporal side are oriented horizontally and vertically; this means that orthoscopy is preserved in that area. While orthoscopy may not be as well preserved in the nasal periphery of the progressive zone, this is not objectionable because much of the nasal side is removed by edging for spectacles frame glazing.

It is to be understood that the term "lens" as used herein is intended to include the ophthalmic product in any and all forms common to the art, i.e. including lens blanks requiring second side (concave or convex) finishing as well as lenses finished on both sides and "uncut" or "cut" (edged) to a size and shape required for spectacles frame glazing. The present lenses may be formed of glass or any one of the various known and used ophthalmic plastics. If second side finished, i.e. on the side opposite that having the progressive power surface, the second side may have prescription surface curvatures applied with the lens RP decentered in usual fashion.

Those skilled in the art will readily appreciate that there are various forms and adaptations of the invention not discussed herein which may be made to suit particular requirements. Accordingly, the foregoing illustrations are not to be interpreted as restrictive beyond that necessitated by the following claims.

I claim:

1. In a progressive power ophthalmic lens having two refractive surfaces one of which is divided into three viewing zones comprising an upper distance portion, an intermediate progressive portion and a lower near portion, and having a principal vertical meridian defined by a sequence of points traversing said zones, wherein said distance portion occupies approximately the upper half of said lens and is of substantially spherical configuration providing a substantially constant focal length for distant vision, wherein said near portion occupies a lower portion of said lens and is of substantially spherical configuration providing a substantially constant focal length for near vision, and wherein said intermediate progressive portion lies between and has defined boundaries with said distance and near portions and has a varying curvature which increases continuously and progressively along said meridian from a minimum